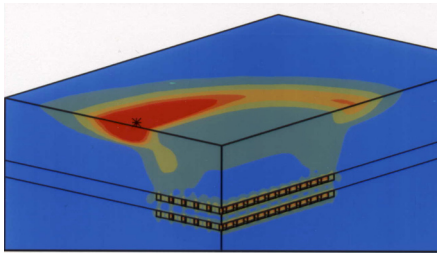
Sandia National Laboratories

Underground Storage Technology Department

Focus

The Underground Storage Technology Department provides technology to support the Department of Energy's Strategic Petroleum Reserve (SPR) and industry in the planning, development, and operation of large underground salt caverns for the storage of liquid and gaseous hydrocarbons. Department staff focus internally on site planning, geological investigations, cavern and subsurface mechanics, fuel chemistry, operational analyses, and salt leaching analyses while also directing additional Sandia project support in materials, fluids, and other needed areas of expertise.



Analyzed Stress Pattern Associated with a Room and Pillar Salt Mine

Technical Activities

Underground Storage of Crude Oil and Natural Gas

Site Characterization

Brine Disposal

Site Planning of Storage Facilities

Cavern Development and Modeling

Cavern Operational Analyses

Cavern Mechanics

Subsidence Modeling

Cavern Integrity Testing

Processed Acoustic Image of a Leached Storage Cavern

Selected Achievements and Current Projects

Cavern Leaching: Sandia developed the salt vertical cavern leaching code SANSMIC which simulates stages of direct and reverse leaching and uniquely features a leach/fill option for cavern development. The code has been validated and used for the development of over forty caverns. Additionally, the horizontal cavern leaching code HORSMIC has been developed for bedded salt applications.

Storage Site Development: We have developed the data base and models for the optimized development of storage sites containing either single or multiple caverns. This capability is being and has been used to locate caverns on sites, and develop in an optimized manner either single caverns or arrays of caverns. The caverns are located, sized, and developed in a manner which preserves stability and operational constraints, while minimizing workovers and overall development time.

Sandia is a multiprogram laboratory operated by Sandia corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

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Leach Scheduling: In response to SPR's necessity to minimize site cavern development time, a site optimization scheduling model for leaching caverns has been developed. The model optimally allocates raw water, workover rigs, etc.

Gas Storage: With industry we have developed methods of gas storage caverns using gas as a blanket material during cavern leaching. The cost of the caverns has been minimized by optimizing the leaching stages, minimizing cavern workovers, and allowing for early gas storage.

Cavern Integrity Testing: For the U.S. SPR, we developed the concept and procedure for integrity testing salt cavern wells using nitrogen. With nitrogen testing, SPR was able to reduce detectable leak rates by orders of magnitude, thus minimizing potential environmental damage and oil loss. The practice of nitrogen testing has been adopted by industry and is now recognized by the Louisiana and Texas regulatory agencies. Additionally, we have developed and implemented automated salt cavern monitoring and pressure prediction capabilities.

Salt Cavern Mechanics: We have developed an analysis capability to investigate salt stress/strain/creep associated phenomena. Stresses and resulting creep, dilatancy, and subsidence have been modeled for existing caverns and shafts. The models have been validated by cavern closure data and surface subsidence measurements. Associated salt stability criteria developed by Sandia for WIPP have been applied to individual caverns and arrays of caverns in order to predict long-term responses to both existing and possible operational or development scenarios.

Projections of long-term subsidence and associated casing strains/stresses have been developed. This has allowed plans to be developed for the mitigation of potential site flooding on sites which are susceptible to local or seasonal flooding. This work has also been used to form the basis of comprehensive surface leveling grids which are surveyed annually.

Long-Term Stored Product Stability: We continue to provide technical analyses and reviews of the effects of long-term storage on stored products, most significantly crude oil. Models have been developed to predict the effects of downhole thermal absorption, gas absorption, and internal circulation, on caverns with crude oil. An analysis capability has also been developed to predict the effect of pipeline thermal losses/gains on delivered products.

Salt Cavern Siting: In response to the original Strategic Petroleum Reserve development, and subsequent expansion programs, we have maintained a comprehensive data base on Gulf Coast salt domes, with particular emphasis on the larger on-shore domes with significant storage potential. Associated geological information relative to brine disposal near the domes has been evaluated, including injection wells.

Materials Development: We have developed with industry a light-weight epoxy material which floats on oil and cures to form effective bases for isolation bulkheads for penetrations in salt.

Site Geotechnical Characterization: Sandia has characterized each of the SPR sites used for storage regarding those factors that affect storage integrity. Geologic structure, salt properties, groundwater, and environmental factors are evaluated prior to cavern emplacement, and periodically reevaluated to ensure safe and environmentally acceptable storage.

Corrosion Monitoring and Materials Development: We have operated a corrosion test loop for pipeline coatings in brine environments. Concrete linings have been extensively characterized. Corrosion monitoring probes and techniques for in situ pipeline corrosion measurements have been developed and data collection is ongoing.

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